DOCUMENT RESUME

ED 474 717 SE 067 667

AUTHOR	Baldwin, Brian; Sheppard, Keith
TITLE	In Search of Pedagogical Technology Content Knowledge: The Role of the Teacher Preparation Program.
PUB DATE	2003-03-23
NOTE	30p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (Philadelphia, PA, March 23-26, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	Concept Formation; Decision Making; Higher Education; Preservice Teachers; Professional Development; Science Education; *Teacher Attitudes; *Teacher Education Curriculum; *Technology Education

ABSTRACT

This study investigated how computer technology was integrated into two science courses within the pre-service science education program at a graduate education college. The research focused on the approaches that teacher educators used to incorporate technology within these classes as well as the attitudes, beliefs, and behaviors that underlie their use of computer technology. The pre-service teachers' interaction with technology was studied throughout these classes. Special emphasis was placed on the instructor's pedagogical decisions regarding the structure of each class session and its impact on student understanding. (KHR)

In Search of Pedagogical Technology Content Knowledge: The Role of the Teacher Preparation Program

Paper presented at the annual meeting of the
National Association for Research in Science Teaching,
Philadelphia, PA, March 23-26, 2003

Brian Baldwin and Keith Sheppard
Department of Math, Science, and Technology
Teachers College, Columbia University
New York, NY 10027
Contact: Brian Baldwin, bcb12@columbia.edu

Introduction

While there is a broad body of literature in science education, teacher education, and educational technology dealing with classroom use of technology, little has been written about computer technology integration techniques within subject-specific, teacher education classes. This study seeks to remedy this deficiency. Previous research on pre-service science teachers' attitudes and beliefs about teaching and learning with technology has mainly focused on the effect of separate educational technology courses. In this study, we investigated how computer technology was integrated into two science courses within the pre-service science education program at a graduate education college. The courses, Concepts in Chemistry II and Concepts in Physics I, were chosen because they represent courses that aim to develop knowledge of scientific content with an understanding of effective pedagogical practice. While the larger study has focused on both of these courses, this paper focuses solely on the Concepts in Physics I course.

The research focused on various aspects of the courses. Specifically, the approaches that teacher educators used to incorporate technology within these classes, as well as the attitudes, beliefs, and behaviors that underlie their use of computer technology. Additionally, the pre-service teachers' interaction with the technology was studied throughout these classes. Special emphasis was placed on the instructor's pedagogical decisions in deciding the structure of each class session, and its impact on student understanding. It is hoped that the results from this study will aid science teacher educators in developing more effective practices for their classes.

The Present Status of Science Education

Two recently published reports have outlined troubling aspects of science education in U.S. schools. The Nation's Report Card detailed student science achievement in 4^{th}, 8^{th} and 12^{th} grades (U.S. Department of Education, 2001), while the Third International Mathematics and Science Study (TIMSS) compared US student achievement with their international counterparts (U.S. Department of Education, 1999b, 2000). Both of these studies documented the relatively poor achievement in science of American students, particularly at the high school level. The studies further criticized the teaching methodologies used in U. S. science classrooms as being overly didactic and teacher centered. While two thirds of teachers reported that they placed heavy emphasis on developing students' interest in science, the students reported that lecture and worksheets were their most common activity in class. Approximately half of the students reported, for example, that their teachers did not use computers in instruction in science. Notably, students whose teachers emphasized understanding of key concepts, development of laboratory skills, or performing hands-on activities were more likely to perform at or above the "Proficient" level, as measured by the researchers, than those who did not (U.S. Department of Education, 1999a).

These problems with student achievement and teacher practice and the calls for the reform of science education are not new. A brief review of the literature reveals that science education has been in a constant state of reform for the past century (Bybee, 1993; DeBoer, 1991; Hurd, 1997). These reform efforts have been targeted at several different levels. At the curricular level, there have been efforts to reorganize the traditional biology, chemistry and physics sequence of sciences (Lederman, 2001), or to emphasize an increased relationship to societal and technological issues (Yager, 1996).

At the pedagogical level, examples of reform include advocating constructivist approaches of pedagogy, inquiry-based learning, project-based learning, and technology-enhanced teaching and learning (Edelson, Gordin, & Pea, 1999; Polman, 2000; Woolsey & Bellamy, 1997). At the policy level, reform efforts have included moves to increase science requirements for high school graduation or college entrance, and proficiency of certain concepts as measured by standardized tests (Hodas, 1993; Loveless, 1996).

A notable, recent reform effort has ambitiously set as its goal the improvement of the scientific literacy of all of the nation's students (American Association for the Advancement of Science, 1990, 1994; National Research Council, 1996). One result from this movement was the development of the *National Science Education Standards* (NSES). On a basic level, the NSES detail what students should know about science at various points in their schooling(National Research Council, 1996). Although the NSES are generally thought of as just a list of concepts and scientific processes that students should master, they also contain standards for the professional development of science teachers, as well as standards for science education programs and science education systems. According to the standards, "what students learn is greatly influenced by how they are taught" (National Research Council, 1996, p. 28). Consequently, the standards also provide guidelines for science teaching. The teaching standards describe what teachers of science should know and be able to do, while the professional development standards "present a vision for the development of professional knowledge and skill among teachers" (National Research Council, 1996, p. 4).

An important aspect of these reform efforts concerns the appropriate role and use of computer technology in science classes. NSES professional development standards for teachers calls for them to design "courses that are heavily based on investigations, where current and future teachers have direct contact with phenomena, gather and interpret data using appropriate [computer] *technology* [italics added], and are involved in groups working on real, open-ended problems" (National Research Council, 1996, p. 61, my italics). The NSES contain no specific recommendations about how to use computer technology in the science classroom.

The International Society for Technology in Education (ISTE) has also developed a set of technology standards for teachers, the *National Educational Technology Standards* (NETS) (International Society for Technology in Education, 2002). The technology standards are written to recognize the different technology proficiencies that are required for teachers at different stages of their careers – from education courses through professional development as practicing teachers. However, these technology standards are not discipline-specific. The NETS include: technology operations and concepts for computers; the planning and designing of learning environments and experiences using computers; how to assess and evaluate technology projects; productivity and professional practice through the use of technology; and the social, ethical, legal, and human issues associated with technology use (International Society for Technology in Education, 2002).

The Association of the Education of Teachers of Science (AETS) has developed a position statement on the professional standards for teacher educators (Association for the Education of Teachers of Science, 1997). Surprisingly, the AETS position statement does not mention any standards for technology use by science teacher educators. Without these recommendations in place, it is not difficult to see why science teacher educators and science education programs have few, if any, requirement for the technology proficiency of their graduates.

Why Computer Technology Should Be Used in Science Education

Computer technology has become prevalent in today's society, providing personal and professional productivity tools, warehouses for storing information, as well as aids in collecting and sharing information. Computers are particularly valuable tools for investigating scientific phenomena and are frequently used by scientists in their work. For example, scientists use computer technology in many different ways: for real-time data collection, for visualizations/simulations, for molecular modeling and for helping to provide glimpses into processes that occur at levels too small to be detected by human senses. Scientists rely on skills of observation, as well as methods and instruments for viewing and analyzing data. In this respect, computers offer superior, more precise instruments for conducting scientific investigations and have become an indispensable tool for many scientists.

The NSES call for science teachers to promote scientific inquiry and to teach science the way that it is conducted. In science teaching, there are many ways that teachers can introduce and investigate scientific concepts with their students using computers. Computers can be used to make dynamic visualizations by representing sub-microscopic phenomena. They can be used to demonstrate phenomena that might be either too dangerous or too costly to perform in a science classroom. The collection and analysis of real-time data from observations in the field and the laboratory mirrors the process of science as practiced by scientists.

Additionally, if used effectively, computer technology can enhance students' higher order thinking skills (Moore, 2000). The recent NAEP report showed that there were statistically significant differences in student achievement when students were exposed to frequent use of different computer technologies: collection of data using probes, downloading data, and analyzing data (U.S. Department of Education, 2001). As reform measures in science education call for a greater emphasis on the nature and practice of science, the integration of computer technology into K-12 classrooms as well as teacher education programs is a step in this direction. But what are the issues that surround such implementation?

Teacher Reform and Technology Implementation

Despite the rapid integration of computers into everyday personal and professional lives, successful integration into K-12 classrooms has lagged behind. There are many reasons for this situation. It has long been known that in the absence of compelling reasons to do otherwise, new teachers simply revert to teaching in the way they themselves were taught. Teachers have been taught to act as transmitters of the information rather than as guides to inquiry, with students assuming the role of passive assimilators of the information (Schofield, 1995). Using technology as a tool for learning means teachers must begin to work as facilitators to the students' learning process. Further, for most teachers, computer technology was absent from their own education. Consequently studies report little or no use of technology in the classrooms of new teachers (Persichitte, Caffarella, & Tharp, 1999; White & Frederikson, 1998).

To end this cycle of non-use, reforms in teacher education programs have called for additional "training" for pre-service teachers in the use of technology in the classroom

(Barker, Helm, & Taylor, 1995; Stetson & Bagwell, 1999). Technology specialists have called for an integration of computer technology skills within actual curriculum and methods classes in the specific disciplines, as opposed to "stand alone" technology classes which are divorced from the pedagogical content of the traditional methods classes (Brush, 1998; Dugdale, 1994; Zachariades & Roberts, 1995). However, the formulation of a method of "best practice" has not been established. Case studies of different education programs have been published (Levin & Buell, 1999; Pellegrino & Altman, 1997; Thompson, Hanson, & Reinhart, 1996), yet it appears that successful practices that might work in one institution might not be successful in another. Unfortunately, many teacher educators themselves do not feel prepared to use or model successful technology practices (Mitra, Steffensmeier, & Lezmeier, 1999).

There are also a number of additional barriers to technology implementation at both the K-12 level as well as in teacher education programs. Several studies have shown that such barriers include lack of time, software, equipment, information, and support (Germann & Sasse, 1997; Persichitte et al., 1999; Sandholtz, Ringstaff, & Dwyer, 1997; Schofield, 1995; Wetzel, 1993). So how can technology be integrated into science education programs?

Technology Integration

One method used to overcome the disconnect between science as practiced and science as taught is through the use of an 'infusion-based' technology component in teacher education courses (Drazdowski, Holodick, & Scappaticci, 1998; Gillingham & Topper, 1999; Pellegrino & Altman, 1997; Schrum, 1994; Vannatta & O'Bannon, 2001). A critical issue is the placement of the computer technology integration within the science teacher preparation program. Should computers be integrated throughout the program, instituted as a separate course, or some combination of both?

One proposed method of the integration of computer technology in this study is situated within the conceptual framework of cognitive apprenticeship (Collins, Brown, & Newman, 1989). Cognitive apprenticeship is an application of situated cognition theory, suggesting that learning is naturally tied to authentic activity, context, and culture (Brown, Collins, & Duguid, 1989). A critical component behind this framework is the need for teacher educators themselves to be well-versed in the uses of teaching with technology, and be able to model these uses to the pre-service students. Cognitive apprenticeships involve students working in teams with scaffolding and support from the instructor, with gradual fading of the support as the students apply their learning to authentic problems (Collins et al., 1989). The use of modeling appropriate practices of technology use within pre-service science teacher classrooms is considered vital to the integration of skills of teaching with technology (Barker et al., 1995; Frances-Pelton, Farragher, & Riecken, 2000; Handler & Marshall, 1992; Persichitte et al., 1999; Salpeter, 2002; Vannatta & O'Bannon, 2001; Wetzel, 1993; White & Frederikson, 1998; Zachariades & Roberts, 1995; Zhao, Pugh, Sheldon, & Byers, 2002).

Attitudes and Beliefs

One method of predicting and analyzing behavior of teachers is to study their self-stated attitudes and beliefs. Attitudinal surveys have been shown to be significant predictors of computer usage for teachers and teacher educators (Huang, 1994; Levine & Donitsa-Schmidt, 1998; Waight, Abd-El-Khalick, & Brown, 2002). Consequently, it is imperative to look at the beliefs and attitudes of both preservice teachers as well as teacher educators when investigating technology integration practices within teacher preparation programs.

Many studies have been published about the attitudes and beliefs of preservice teachers' comfort and experience with technology (Blake, Holcombe, & Foster, 1998; Boone & Gabel, 1994; Davidson & Ritchie, 1994; Laffey & Musser, 1998; Levine & Donitsa-Schmidt, 1998; McEneaney, 1992). Researchers found that, in general, pre-service teachers had relatively low levels of self-reported computer skills besides word processing, email, and Internet skills (Drazdowski, 1994; Gabriel & MacDonald, 1996; Pope, Hare, & Howard, 2002). Other studies have shown that the possession of these personal and managerial skills are necessary in order for teachers to become proficient in teaching with technology (Reiber & Welliver, 1989; Sandholtz et al., 1997; Zhao et al., 2002).

A specific attitude studied by researchers in the field of educational technology is the self-reported characteristic of efficacy. Self-efficacy has been defined as the self-perceived ability to cope with situations through one's own behavior (Bandura, 1977). For technology-using teachers, self-efficacy has been defined as the ability to be personally effective as a technology-using teacher (Kellenberger, 1996). This can be thought of as self-confidence in one's own technology-using skills. It is believed that values of self-efficacy are helpful predictors in future usage of technology in the classroom. This feeling of self-efficacy relates directly with comfort level to proposed technology innovations in the classroom. Regarding pre-service teachers, studies have shown that there is a strong disconnect between the perceived value of teaching with computers and reported self-efficacy of teaching with computers (Albion, 2001). There is a general trend that pre-service teachers who report low values of self-efficacy are less likely to integrate technology into the courses they teach (Brush, 1998). This tells us that in order for pre-service teachers to be willing to integrate technology into the courses that they teach, they must first feel comfortable with the technology – they are not inclined to teach with an unfamiliar tool. Indeed, it should be the charge of teacher education programs to raise the reported self-efficacy values of its pre-service teachers by allowing their comfort levels to increase with greater and sustained exposure to teaching and learning with technology.

Research on the factors involved in teachers' behavioral change through technology is emerging (Dexter, Anderson, & Becker, 1999; Kluever, Lam, Hoffman, Green, & Swearingen, 1994; Strudler, 1991; Wilburg, 1997), as well as the influence of change at the institutional level (Fullan, 1991; Schofield, 1995). Research has shown that changes in teachers' behavior using technology are in line with Bandura's (1977) research of increasing self-efficacy (Brownell, 1997; Frances-Pelton et al., 2000; Levine & Donitsa-Schmidt, 1998).

Research Questions

What impact do the instructors have on the integration of computer technology into subject specific courses? Specifically:

1. What role do the attitudes and beliefs of the instructors have on the integration of computer technology into their classes? Do their behaviors match their attitudes?

2. How does computer technology impact the instructors' educational decisions and their own teaching processes?

3. Is computer technology use being modeled, or are the instructors simply using the technology?

Data Collection

This research primarily used a case study methodology. Case studies have been used in education research in multiple ways. Case studies often involve an in-depth analysis of the setting and context of the case (Creswell, 1998). A defining characteristic of a case study is that the object of study is bounded both in time and in place (Creswell, 1998; Merriam, 1998). Providing for the need for these rich descriptions, we observed and videotaped every session of each of these courses. The observations included taking field notes and conducting informal interviews and recording interactions with the students and instructors during the courses. The field notes for each class were transcribed for thematic analysis. From these notes, we were able to document the techniques that the instructors used when teaching the course with and without computer technology.

We studied the processes by which the instructors integrated the teaching and learning of content and pedagogy with technology into their courses by conducting formal, structured interviews outside of the classes with the instructors as well as the students. Additionally, we conducted interviews with the instructors after each class session for their feedback and rationale for pedagogical decisions in their structure of the class session. The interviews were audiotaped and transcribed. Introductory interviews with each instructor and students were conducted to ascertain their beliefs, attitudes, and philosophies to teaching and learning prior to the course. The follow-up interviews throughout the semester focused on the development of these attitudes and beliefs as a function of the progression of the course.

Case studies are also categorized by multiple sources of information besides observations and interviews (Creswell, 1998). We also obtained and analyzed course documents from each of the classes as well as the degree requirements for the Master of Arts in Science Education.

Classroom Setting and Student Demographics

The class met in a traditional chemistry teaching laboratory, with a chalk board and stationary demonstration bench at the front of the room, lab benches with sinks, electric, and gas along two sides of the room, and four chem-top tables in the middle of the room, each accommodating four students in close quarters. The class was capped at 16 students because of classroom space limitations, and there was a waiting list of 6 students. With 16 students enrolled in the Concepts in Physics course, this made for a very tight classroom. Of the 16 students enrolled, there were nine who were pre-service, and the remaining seven were in-service teachers. The inservice teachers' classroom experience ranged from one year of teaching, to over 10 years of experience. One unique student enrolled in the course was an experienced high school biology teacher who had recently become an assistant principal in charge of the science department at his high school. He was enrolled in the course so that he could be exposed to innovative techniques of teaching physics so that he could supervise his physics teachers and prospective physics teachers accordingly. Interestingly, six of the seven in-service teachers had taught with technology before, and five of those six had used probes and real-time data collection in their teaching. Another interesting fact to note is that 11 of the 16 students in the class stated that they are either teaching physics or will be teaching physics. There were ten males and six females. All of this student demographic information was gathered from either the introductory student information surveys or the interviews with the students.

Results and Analysis

Attitudes and Beliefs of the Instructor

To answer Research Question 1, data was collected from course documents, transcribed interviews with the instructor, as well as in-class observations and from interviews with the science education department members. The instructor for the course was an experienced middle school and high school science teacher. He had taught for many years in a school that had integrated computer technology into the K-12 science program. Additionally, the instructor had worked for several summers in workshops aimed at teaching physics with technology. Prior to his science teaching career he had worked as an archaeologist and an aerospace engineer. Implicitly appealing to students in the class with strong science backgrounds as well as those in the class with teaching experience, he was able to alleviate skeptics of his content knowledge and of his pedagogical expertise.

During previous semesters, the course had been taught by a different instructor in a traditional manner with lectures sprinkled with some hands-on activities, as well as homework involving numerical calculations. The previous instructor was a trained physicist without high school or middle school teaching experience. While the course did heavily emphasize the physics content, there was a disconnect between the usefulness of the in-depth content material of the course, with the usefulness of modeled pedagogical implementation. The impetus of change in the course came from the department level. The department decided that future offerings for the course should strongly in line with contemporary science teacher education research. Therefore, the new instructor was selected because of his knowledge of the content, the application to high school and middle school physics classrooms, and his teaching methodologies.

The instructor was willing to take risks. While he had not previously taught this course, he had a great deal of experience of teaching the same content material with the technology to other teachers through some professional development initiatives. Given the opportunity to teach the content of the course as outlined in the description in the catalog, he had the liberty of presenting the material in his own method.

The instructor's teaching experience led him to teach in constructivist manner. Prior to investigating new concepts, the instructor gave a pre-test to the students. The first pre-test consisted of an array of questions focused on forces and motion. Another pre-test later in the semester consisted of an analysis of a dialogue between two students explaining, in their words, the forces on a coin after it is tossed in the air. By having his students analyze this dialogue, as well as perform the other pre-test, the instructor was emphasizing his desire to find out what the students already know, as well as expose them to common student misconceptions in the same material that they are investigating in the course. These characteristics fit within the paradigm of constructivist patterns of teachers (Novak, 1988).

The major foci of the semester-long Concepts in Physics I course was a blend of motion, forces, and heat and temperature with modeled pedagogical strategies of teaching the content. Every class session involved the integration of computer technology in the form of the i-book computers with Vernier LabPro interfaces and different sensors (motion detectors, force probes, and temperature probes). The research-based curriculum that the students followed focused on challenging fundamental student misconceptions with investigations using student interactions with the technology in order to better understand the physics content.

Following the methodology of finding out what his students already knew, the instructor was then able to tailor his instruction in such a way as to engage the students in a dialogue with him as well as each other, as illustrated by this exchange with a group of three students (all females), discussing the differences between position vs. time graphs with velocity vs. time graphs. The students are working with a motion detector attached via an interface to a laptop computer. They are measuring their own movements in front of the motion detector and analyzing simultaneous representations of their position vs. time, as well as velocity vs. time graphical representations.

> Instructor: Where's the zero on the position-time graph?
>
> Student 1: You have to be right on it (the motion detector). But I can't.
>
> Instructors: It's zero here in the middle of this picture (referring to the velocity vs. time graph), but what do you notice on the position-time graph? Where's the zero in this graph? Is it on the middle of this graph?
>
> Student 1: No.
>
> Instructor: So if something falls below zero, what is that? Can you have a negative distance?
>
> Student 1: No.
>
> Instructor: So, what does that mean?
>
> Student 1: It means that you have to be behind the detector, which makes no sense.
>
> Instructor: (Pointing to a different place in the graph) If it's up here, which way are you moving?
>
> Student 1: I'm moving away, and then I'm moving toward.

Student 2: But that's not right.

Student 1: I'm moving away then towards.

Instructor: But here you're not moving right? Here you're not moving. Here you are (pointing to a different location). Which way are you moving?

Student 1: Away

Student 3: Here you're moving away. This here is just the change that occurs (on the graph) from not moving. So it's not like you're moving toward me.

Instructor: That's good. So, down here what do you do?

Student 1: I'm going to steadily go away.

Instructor: Which direction?

Student 2: You really can't think of the velocity time the same as the position time.

Student 1: It's the same.

Student 2: No, it's a little different. Over here it's velocity time. As (Student 3) was saying here you're at zero velocity. And then over here…

Instructor: I like all of your thinking here. It's kind of being stuck on the position time graph, but now it's a different animal.

To address Research Question 2, data came from the interviews with the instructor as well as observations in the classroom. The structure of the physical layout of the room combined with the instructor's attitudes and behaviors is where the impact of the computer technology in the course is most strikingly seen. While the course content generally stayed the same according to the catalog description, the new instructor decided to have the students learn physics from more of a constructivist approach, with an emphasis in getting close to the content. He stated, "My assumption is that the closer you get to the learning material, the better." It was his goal to engage the students in hands-on activities to directly involve them in their understanding of physics concepts.

Therefore, all tables and most of the chairs had been removed from the room and six workstations had been set up against two walls of the room. Each workstation consisted of a laptop computer, LabPro interface, motion detector, and appropriate wiring and connections. For the first class session, the computers and sensors were pre-connected. During all other class sessions, the students were responsible for setting up and putting away their workstations. Yet, the instructor made a conscious decision to move the heavy tables and chairs out into the hallway, because, in his words, "...the point is that I could! Certainly if I could not get them out of the room, I'm in a real challenge to adapt to that situation." He believes that the physical layout of the learning environment is crucial for the success of the learning to occur:

> "The curriculum required space: chairs, tables were in the way. A general theory about this is that that room wasn't arranged to suit the learning environment which includes computers. They need space to walk in front of the motion detector. About three to four meters of direct line of sight in front of the detector.
>
> The room itself expects a certain kind of education to occur. The position of the board, the demonstration top, where electricity is, where the gas is, where the cabinets are. They kind of suggest a philosophy of teaching: what's going to happen in the room. So my idea is for us to make the room very flexible. So you need these tables to move out. In this case we only had one alternative, and that was to move them out into the hallway."

Yet, the instructor did have other options. Still fitting within the framework of the research-based curriculum that he was following for the course, he could have chosen the method of integrating an interactive lecture demonstration.

> "I'm in a challenge to adapt to that situation. I still wouldn't have given up on the general parts of the curriculum. The idea of what do you do when you can't get at them, and you can't move the room. What do you

do? And you have all of these theories about learning, what do you do then? You have a crowded classroom, limited equipment, confined spaces, you have certain student populations. All of these will effect your decision as a teacher. In the case where I couldn't move these tables, or there were too many students, it's my challenge to figure out what to do. In this case, it would have been an interactive lecture demonstration where I would still try to preserve the interactive aspects of the learning, but still use the research-based curriculum I intended on learning, the motion detectors, and feedback where you might get one individual to demonstrate the motion in front of the motion detector and get other people to predict and analyze the motion and get them to work in groups in doing that. Making predictions, create the process of the interactive lecture demonstration (ILD) is for a large format classroom. What do you do then? You have one set of equipment, you can do a demonstration which contains the pedagogically-appropriate aspects like prediction phases, a convince-your-neighbor phase, and then a re-prediction, and then you see an actual display of data and then you see a reflection of that data in your predictions.

My assumption is that the closer that you can get to the learning material, the better. So, the interactive lecture demonstration has the students somewhat removed from it. But it's the best option of other alternatives, which is simply for the teacher to lecture from the head of the class. My own thinking was that I wanted the students to have this experience, and for it to be their own as much as possible. Therefore we capped the size of the class, and that decision is based on political decisions, like how small of a class could I get away with, and how small depends on how much equipment I could have, and how big the space was. My point was to bring the whole system to almost a one-on-one tutoring. The closer that you can get to that ratio, the better."

According to the instructor, his teaching experience told him that it would result in a better learning experience for his students to engage them more directly in the material, which meant the opportunity for them to work in small groups of two or three students, as opposed to a whole-class discussion. In fact, we can see that it would have required less effort in setup and room re-arrangement to conduct the class with the interactive lecture demonstration method. Yet, the instructor made a conscious pedagogical decision that in order for the students to deeply construct their knowledge of the content via the use of the technology, the effort of moving the tables and chairs out of the lab room more easily provided this opportunity for the students.

To answer Research Question 3, data was obtained from classroom observations. A few weeks into the course, as the content moved towards the more advanced topics of acceleration and forces, the instructor decided to switch the classroom layout and instruction of the material to the interactive lecture demonstration model. Originally, the decision was made to switch to this teaching style because an equipment order of four low-friction tracks had not arrived. However, the tracks did arrive about five days prior to the scheduled class meeting. Yet, the instructor still decided to continue with his plan of presenting the material on acceleration and forces in the interactive lecture demonstration model. His rationale for this was one of modeling a teaching methodology for the teachers who might have maybe only one set of demonstration equipment in their classrooms, or those with classrooms with furniture that cannot be moved.

> "I hope to give them another way of looking at this interactive style by doing it with a whole class, what you would find in a typical classroom. Many students sitting in rows and files, with the teacher in front with one set of demonstration equipment. So this is a lesson about how that might be done."

In addition to the rationale of modeling the teaching method of using the ILD, the instructor also felt that some of the students in the class were not quite at ease with the interactive nature of the microcomputer-based laboratories in general, and that some of the students were not quite as active using the equipment as he would like.

> "It's meant to address some of the students in the classroom who are finding the MBL and the groupwork associated with the MBLs, and small groupwork, somewhat intimidating. So, it's meant to be a closer bridge between where they're at and where we're going in the course. They hopefully see a parallel between their own experience in large lecture halls in colleges and high school classroom and their own teaching positions.

> What it looks like. It looks very similar – teacher in the front, students back in the back, and everybody's looking at the front. But how do you turn that into an interactive classroom with computers and research-based, etc."

So, as far as the instructor's pedagogical decisions for switching these two classes to the ILD format, he was basing his rationale on both pedagogical as well as content reasons. He wanted the students to experience the curriculum in a format that might be closer to their own previous experience as a science student, but also closer to what their classroom teaching situations were more likely to be like. Additionally, the instructor was using the technology in order to more closely bring the students in contact with the concepts that were under investigation. While a more traditional approach might have been to allow the students to use a ticker timer to measure distances, and calculate velocities and accelerations, the instructor was clearly moving beyond that type of instruction. He realized that a real-time representation of the data made possible only with the use of the technology allowed the students to interact with this material, whether in the form of small groups with individual workstations, or in a whole-class ILD format.

It is, however, interesting to note the instructor's stance on explaining his rationale to his students regarding some of his pedagogical decisions. Not only does the instructor believe that didactically lecturing to students on science concepts provides the students with no functional understanding of the content, he also believes that the same reasoning applies to teacher education. He feels that by explicitly telling students his rationale for the ILD, he would be depriving them of an opportunity to realize and discover for themselves some practical applications of this type of technology integration into their own classrooms:

> But, I wouldn't say this is what you can do, certainly straight away. They need a chance to think about it themselves, to make those connections themselves. If they can, then it will be with them forever. If I say it, I'll bet that I'm just kind of taking a chance away where they can make that connection and actually learn that. Like, "I can do that in the classroom and it will pretty easy to do".

Implications

Concepts in Physics I was certainly a pivotal point in the progression of this class of preservice and inservice teachers, as well as a possible microcosm for pedagogical decisions that can inform better practices in science education programs struggling to identify methods of integrating technology into their curricula. The ideas that the instructor addressed in this course is not limited solely to Concepts in Physics I. Looking at the big picture, the instructor was teaching a physics pedagogical content knowledge (PCK) course, and attempting to integrate technology in a manner which he felt would aid in the students' understanding of both the physics content as well as current teaching methodologies.

Clearly, the instructor practiced constructivist approaches to science education, with regards to both the physics content of the course, as well as the pedagogical content of the course. The computer technology with the real-time data collection and graphical analysis was certainly a major focus of the course, regardless of the attempt to make the technology be more "transparent" to both the instructor and the student. The question that still remains to be answered is if there is something inherent about teaching with technology that is different from simply teaching. In other words, extending the argument, can technology simply be thought of as a tool to *teach* with, or should there be specific "teaching with technology" methods that are worth investigating?
Correspondingly, another unanswered question is the degree to which both pedagogy and

content are truly intertwined. Should there be dedicated sections in a PCK course which are dedicated to pedagogical issues or content issues? The pedagogical decisions that this instructor made involving the use of technology integration into this physics PCK course is but a small glimpse into this question. It is interesting to note that for this instructor, and for this course, the question involving technology was not "if", but "how". In his view, there was no question that the integration of the technology was going to bring about a closer interaction between the pedagogical content and the student.

Through this brief view of the impact of technology integration in this science teacher education course, we are able to get a sense of some of the struggles and the decisions made by the instructors and the students in order to learn the content of science by being closer to the material. As a tool, technology allows the instructors as well as the students to more easily bring about this closeness.

Further analysis of the data is currently underway for a second phase of this project. An emergent theme seems to be the difference in perceptions on the role of the technology within the teacher education classroom. As more analysis and conclusions are drawn from this data, this will also provide another glimpse into the pathways of integrating computer technology into science teacher education.

Bibliography

Albion, P. (2001). Some factors in the development of self-efficacy beliefs for computer use among teacher education students. *Journal of Technology and Teacher Education, 9*(3), 321-347.

American Association for the Advancement of Science. (1990). *Science for All Americans*. New York: Oxford University Press.

American Association for the Advancement of Science. (1994). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Association for the Education of Teachers of Science. (1997). Professional knowledge standards for science teacher educators. *Journal of Science Teacher Education, 8*(4), 233-240.

Bandura, A. (1977). Self efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Barker, B. O., Helm, V., & Taylor, D. R. (1995). *Reforming teacher education through the integration of advanced technologies: Case Study report of a college model*. Macomb, IL: Western Illinois University.

Blake, S., Holcombe, L., & Foster, D. (1998). Technology and teachers: An investigation of attitudes and beliefs of introductory use by preservice teachers. *Journal of Technology and Teacher Education, 6*(1), 39-49.

Boone, W., & Gabel, D. (1994). Computers and preservice elementary science teacher education. *Journal of Computers in Mathematics and Science Teaching, 13*(1), 17-42.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-41.

Brownell, K. (1997). Technology in teacher education: Where are we and where do we go from here? *Journal of Technology in Teacher Education, 5*(2/3), 117-138.

Brush, T. A. (1998). Teaching preservice teachers to use technology in the classroom. *Journal of Technology in Teacher Education, 6*(4), 243-258.

Bybee, R. W. (1993). *Reforming Science Education: Social Perspectives and Personal Reflections*. New York: Teachers College Press.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L. Resnick (Ed.), *Knowing,* *Learning, and Instruction: Essays in Honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum.

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. Thousand Oaks, CA: Sage Publications.

Davidson, G. V., & Ritchie, S. D. (1994). Attitudes toward integrating computers into the classroom: What parents, teachers, and students report. *Journal of Computing in Childhood Education, 5*(1), 3-27.

DeBoer, G. E. (1991). *A History of Ideas in Science Education: Implications for Practice*. New York: Teachers College Press.

Dexter, S. L., Anderson, R. E., & Becker, H. J. (1999). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Research on Technology in Education, 31*(3), 221-239.

Drazdowski, T. A. (1994). Preservice teachers and computer technology: A case study perspective. *Journal of Technology in Teacher Education, 2*(4), 251-263.

Drazdowski, T. A., Holodick, N. A., & Scappaticci, F. T. (1998). Infusing technology into a teacher education program: Three different perspectives. *Journal of Technology in Teacher Education, 6*(2/3), 141-149.

Dugdale, S. (1994). Integrating curriculum and computers for preservice teachers: Toward a classroom-based experience. *Journal of Technology in Teacher Education, 2*(3), 249-271.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences, 8*, 391-450.

Frances-Pelton, L., Farragher, P., & Riecken, T. (2000). Content based technology: Learning by modeling. *Journal of Technology and Teacher Education, 8*(3), 177-186.

Fullan, M. G. (1991). *The New Meaning of Educational Change (2nd Edition)*. New York, NY: Teachers College Press.

Gabriel, M., & MacDonald, C. (1996). Preservice teacher education students and computers: How does intervention affect attitudes? *Journal of Technology and Teacher Education, 4*(2), 91-116.

Germann, P., & Sasse, C. M. (1997). Variations in concerns and attitudes of science teachers in an educational technology development program. *Journal of Computers in Mathematics and Science Learning, 16*(2-3), 405-423.

Gillingham, M. G., & Topper, A. (1999). Technology in teacher preparation: Preparing teachers for the future. *Journal of Technology in Teacher Education, 7*(4), 303-321.

Handler, M., & Marshall, D. (1992). Preparing new teachers to use technology: One set of perceptions. In D. Carey & D. A. Willis & J. Willis (Eds.), *Technology and Teacher Education Annual* (pp. 386-388). Charlottesville, VA: Association for the Advancement of Computing in Education.

Hodas, S. (1993). Technology refusal and the organizational culture of schools. *Education Policy Analysis Archives, 1*(10).

Huang, S. (1994). Perspective teachers' uses and perceptions of the value of technology. In J. Willis & B. Robin & D. A. Willis (Eds.), *Technology and Teacher Education Annual* (pp. 61-66). Charlottesville, VA: Association for the Advancement of Computing in Education.

Hurd, P. D. (1997). *Inventing Science Education for the New Millenium*. New York: Teachers College Press.

International Society for Technology in Education. (2002). *National Educational Technology Standards for Teachers*. Eugene, OR: International Society for Technology in Education (ISTE).

Kellenberger, D. W. (1996). Preservice teachers' perceived computer self-efficacy based on achievement and value beliefs within a motivational framework. *Journal of Research on Computing in Education, 29*(2), 124-140.

Kluever, R., Lam, T., Hoffman, E., Green, K., & Swearingen, D. (1994). The computer attitude scale: Assessing changes in teachers' attitudes toward computers. *Journal of Educational Computing Research, 11*(3), 251-261.

Laffey, J., & Musser, D. (1998). Attitudes of preservice teachers about using technology in teaching. *Journal of Technology in Teacher Education, 6*(4), 223-241.

Lederman, L. (2001). Revolution in science education: Put physics first. *Physics Today, 54*(9), 11-12.

Levin, S. R., & Buell, J. G. (1999). Merging technology into teacher education: Technology tools and faculty collaboration. *Journal of Computing in Teacher Education, 16*(1), 7-14.

Levine, T., & Donitsa-Schmidt, S. (1998). Computer use, confidence, attitudes, and knowledge: A causal analysis. *Computers in Human Behavior, 14*(1), 125-146.

Loveless, T. (1996). Why aren't computers used more in schools? *Educational Policy, 10*(Dec.), 448-467.

McEneaney, J. E. (1992). Preservice teachers' computer attitudes in non-computer classes.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education.* San Francisco: Jossey-Bass.

Mitra, A., Steffensmeier, T., & Lezmeier, S. (1999). Changes in attitudes toward computers and use of computers by university faculty. *Journal of Research on Computing in Education, 32*, 189-202.

Moore, B. (2000, Feb. 8-12). *Higher Level Thinking Skills and Individual Differences: Bridging Gaps with Technology.* Paper presented at the Society for Information Technology and Teacher Education International Conference (SITE), San Diego.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

Novak, J. D. (1988). The role of content and process in the education of science teachers. In P. F. Brandwein & A. H. Passow (Eds.), *Gifted young in science: Potential through performance* (pp. 307-319). Washington, DC: National Science Teachers Association.

Pellegrino, J. W., & Altman, J. E. (1997). Information technology and teacher preparation: Some critical issues and illustrative solutions. *Peabody Journal of Education, 72*(1), 89-121.

Persichitte, K. A., Caffarella, E. P., & Tharp, D. D. (1999). Technology integration in teacher preparation: A qualitative research study. *Journal of Technology in Teacher Education, 7*(3), 219-233.

Polman, J. (2000). *Designing project-based science: Connecting learners through guided inquiry.* New York: Teachers College Press.

Pope, M., Hare, D., & Howard, E. (2002). Technology integration: Closing the gap between what preservice teachers are taught to do and what they can do. *Journal of Technology and Teacher Education, 10*(2), 191-203.

Reiber, L. P., & Welliver, P. W. (1989). Infusing educational technology into mainstream educational computing. *International Journal of Instructional Media, 16*(1), 21–32.

Salpeter, J. (2002). Training the teachers. *Technology and Learning, 23*(1), 52-54.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. New York: Teachers College Press.

Schofield, J. W. (1995). *Computers and Classroom Culture*. New York: Cambridge University Press.

Schrum, L. (1994). First steps into the information age: Technology infusion in a teacher education program. *Journal of Computing in Teacher Education, 10*(4), 12-14.

Stetson, R., & Bagwell, T. (1999). Technology and teacher preparation: An oxymoron? *Journal of Technology in Teacher Education, 7*(2), 145-152.

Strudler, N. B. (1991). Education faculty as change agents: Strategies for integration of computers into teacher education programs. *Journal of Computing in Teacher Education, 8*(2), 5-8.

Thompson, A., Hanson, D., & Reinhart, P. (1996). One on one technology mentoring for teacher education faculty: Case study reports. In B. Robin & J. D. Price & J. Willis & D. A. Willis (Eds.), *Technology and teacher education annual* (pp. 495-498). Alexandria, VA: Association for Supervision and Curriculum Development.

U.S. Department of Education. (1999a). *Student Work and Teacher Practices in Science*. Washington, DC: National Center for Education Statistics.

U.S. Department of Education. (1999b). *The TIMSS videotape classroom study: Methods and findings from an exploratory research project on eighth-grade mathematics instruction in Germany, Japan, and the United States*. Washington, DC: U. S. Government Printing Office.

U.S. Department of Education. (2000). *Mathematics and science in the eighth grade: Findings from the Third International Mathematics and Science Study: Statistics Analysis Report, July 2000*. Washington, DC: U. S. Government Printing Office.

U.S. Department of Education. (2001). *The Nation's Report Card: Science 2000*. Washington, DC: National Center for Education Statistics.

Vannatta, R. A., & O'Bannon, B. (2001). Beginning to put the pieces together: A technology infusion model for teacher education. *Journal of Computing in Teacher Education, 20*(4), 112-123.

Waight, N., Abd-El-Khalick, F., & Brown, D. (2002, April). *Technology in pre-service science methods courses: Promises and hurdles.* Paper presented at the National Association for Research in Science Teaching National Conference, New Orleans, LA.

Wetzel, K. (1993). Teacher educators' uses of computers in teaching. *Journal of Technology in Teacher Education, 1*(4), 335-352.

White, B. Y., & Frederikson, J. R. (1998). Inquiry, modeling, and metacognition. *Cognition and Instruction, 16*, 3-117.

Wilburg, K. (1997). The dance of change: Integrating technology in classrooms. *Using Technology in the Classroom*, 171-184.

Woolsey, K., & Bellamy, R. (1997). Science education and technology: Opportunities to enhance student learning. *Elementary School Journal, 97*(4), 385-399.

Yager, R. E. (Ed.). (1996). *Science / Technology / Society as reform in science education*. Albany: State University of New York Press.

Zachariades, I., & Roberts, S. K. (1995). A collaborative approach to helping teacher education faculty model technology integration in their courses: An informal case. *Journal of Technology in Teacher Education, 3*, 351-357.

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. L. (2002). Conditions for classroom technology innovations. *Teachers College Record, 104*(3), 482-515.

SE067667

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: In Search of Pedagogical Technology Content Knowledge: The Role of the Teacher Preparation Program

Author(s): Brian Baldwin, Keith Sheppard

Corporate Source:

Publication Date: March 2003

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☒	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here,→ please

Signature: Brian C. Baldwin	Printed Name/Position/Title: Brian C. Baldwin, Instructor of Science Educati[on]
Organization/Address: Teachers College, Columbia University, Box 210, 525 W. 120th St., New York, NY 10027	Telephone: 212-678-8174 — FAX: 212-678-8129 E-Mail Address: BCB12@columbia.edu — Date: 4/14/03